Cladding With High-Power Diode Lasers

High-power diode laser cladding delivers a number of advantages over traditional techniques. In particular, diode lasers produce a high-quality clad with excellent physical characteristics and a true metallurgical bond.

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Cladding is an additive manufacturing process used in a variety of industries for improving the surface properties of a part, or to resurface a component that has become worn through use. There are a number of different techniques for performing laser-based cladding, each with its own specific characteristics in terms of the materials employed, the quality of the clad layer, and various practical issues that include throughput speed, process compatibility and cost.

Cladding involves the creation of a new surface layer on a substrate having a different composition than the base material. It offers the machine or tool builder a very useful degree of freedom in the design. Specifically, it enables the production of parts in which the surface properties of the material are distinct from its bulk properties. Most commonly, cladding is used to enhance the wear, corrosion or heat resistance of a part. For example, a designer might choose a metal alloy for an engine crankshaft that is flexible enough to handle the torsional stresses experienced in a rotating component. Although if this flexible alloy is soft, the bearing surfaces can wear rapidly. To alleviate this challenge, users could clad just the bearing surfaces of the part with a surface layer of a much harder material.

Ideally, the cladding process should result in minimal mixing between the deposited and substrate materials, called dilution — a high-strength, truly metallurgical bond between the cladding and substrate — and minimum thermal distortion of the part being worked. The latter is important because it avoids the need for post-cladding machining to bring a distorted part back into its original dimensional tolerances. Various practical considerations, such as throughput, process compatibility, capital cost and consumables costs, can be equally important.

Traditional cladding methods

Traditional methods of cladding can be broadly classified as either welding techniques or thermal spraying methods. Each has advantages and limitations. There are a number of different arc welding techniques, including gas tungsten arc welding (GTAW), plasma arc welding (PAW), plasma transferred arc (PTA), gas metal arc welding (GMAW) and submerged arc welding (SAW). In all of these processes, an arc is established to melt the surface of the base material, usually in the presence of a shield gas. The clad material is then introduced in either wire or powder form and is also melted by the arc, thereby forming the clad layer.

All arc welding techniques deliver a fully welded, metallurgical bond having not only high-strength, strong impact properties, but low porosity. Such meth-
Lasers in many ways deliver the best of both worlds for cladding applications, as they offer lower heat distortion, reduced dilution of the clad material into the substrate metal, lower porosity and better surface uniformity. Together these properties largely eliminate the need for post-processing, and any associated time and cost. Moreover, laser cladding delivers a metallurgically bonded layer, generally avoiding the cracking and delamination often associated with spray coatings.

High-power laser diode systems are well-matched to the needs of large area cladding applications for several reasons. First, their near-IR wavelength is relatively well-absorbed by most metals. Next, the net conversion of electricity into usable laser light is inherently more efficient (as much as 50 percent) in semiconductors as compared to any other laser medium. In addition, the rectangular-shaped output from a diode laser array naturally facilitates large area cladding applications because this output can easily be re-imaged to a line of laser light. This line is then
industrial parts. The company recently developed a laser cladding system to service cladding, hardfacing and surface treatment applications. This new system is based on Coherent’s HighLight 10000D (10 kW diode laser), and can be configured to produce an output beam width of 6 mm, 12 mm or 24 mm.

“In these applications, the primary benefit of laser cladding is the minimal dilution zone, and the technology delivers better performance in this respect than we can achieve with our PTA welding equipment,” said Castolin sales manager Martin Maierhofer. “By minimizing dilution, the performance of the substrate alloy isn’t destroyed or altered by the cladding process. There’s no burning of the carbon in steel alloys, and the part retains its original bulk properties.”

One application employed by Castolin is cladding of the rollers used in wire drawing equipment. These rollers are fabricated from 30 mm diameter structural steel (S235) pipe. Without any treatment, the narrow wire cuts into the roller during the drawing process, rapidly wearing and damaging it. Laser cladding is used to deposit a 1.5-mm thick layer of Laser LC 8 alloy — a steel alloy containing nickel and a high content of tungsten carbide — around the entire roller circumference. Long sections of pipe are clad, and the end user is able to cut it to length as needed. Diode laser cladding has proven to extend roller lifetime by a factor of more than five times that of past heat treating processes.

The laser cladding technique can also apply to ventilation fan blades used in the cement industry. In operation, airborne abrasive cement particles can quickly wear the steel blades down. HighLight 10000D’s wide beam allows rapid cladding of such blades with a 1-mm thick clad of LC8.

“It’s critical that the cladding process doesn’t mechanically deform these blades, otherwise the fan won’t operate properly when it’s spun at speed,” said Maierhofer, noting that low heat input from laser cladding “doesn’t produce any part distortion, which wasn’t true of our earlier welding process.”

High-power diode lasers are more economical to operate than other cladding laser sources, and integrate smoothly into the production environment. Many cladding experts are rapidly embracing this technology.

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